ENTER: The Personalisation and Contextualisation of 3-Dimensional Worlds

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Abstract

Within this paper we present the details of the ENTER (Environment which Totally Envelops the useR) system. The ENTER system seeks to provide a totally immersive 3-Dimensional environment which is highly configurable and personalised based on the perceived needs of an individual user. The use of agent-orientated modelling and design techniques has lead to a versatile and flexible system within which the constituent agents collaborate to realise the systems aims. The facility to dynamically reconfigure virtual worlds controlled by the agent entities lends to the technology being applicable for differing immersive environments. This system has in the first instance been cast in the arena of virtual shopping malls, but of course this represents but one potential application domain.

1. Introduction

This paper details research conducted within the ENTER (ENvironment which Totally Envelops the useR) project. The ENTER system seeks to provide a totally immersive 3-Dimensional environment which is highly configurable and personalisable based on the perceived needs of the individual user. Additionally like many other such systems the user is not merely immersed in a virtual world but also integrated into a virtual community with the associated evolution of inter-user relationships [1].

In the delivery of the ENTER system we have embraced an Agent-Oriented philosophy [2][3]. The system functionality is delivered via a community of software agents, which collaborate in opportunistic reconfiguration, and re-presentation of the 3-dimensional worldview.

Within the remainder of this paper we briefly examine the research baseline that has motivated this work. We subsequently introduce a high level overview of the ENTER architecture followed by a detailed consideration of each of the constituent agents. In section 5 we reflect on the issues associated with the dynamic reconfiguration within the context of a shared virtual community, section 6 offers some brief conclusions.

2. Related Research

The ENTER project draws upon three areas of research which it seeks to integrate in order to facilitate the pro-active delivery of information in 3-Dimensional (3D) space, those of Agent Oriented Programming (AOP) [2], Virtual Reality [4] and User Profiling. Agent Oriented Programming has been adopted in ENTER in an effort to ensure scalability and flexibility of system design, and draws upon much research already conducted in the area of multi-agent systems [2][5][6]. The use of virtual reality ensures the encapsulation of the agent-based architecture within a familiar and easy-to-use environment [7].

The chosen domain of ENTER is one of a Virtual Retail environment, there are numerous Internet sites that use a 3D metaphor for e-commerce [17][18] but there are none that offer personalization of a site based on users needs. Research into the usability of VR retail environments has proved very positive [19] with large retail chains adopting VR technology. VR technology research has to date been primarily focused on the creation of interactive training environments [7] and design modeling. The incorporation of VR techniques into the commercial domain lends to a very powerful and interactive marketing tool especially when coupled with artificial intelligence profiling techniques. Already user profiling and personalization of content proliferates throughout 2D web sites [8] and within ENTER we seek to use such techniques and to apply them to a 3-dimensional environment.

3. The ENTER Schematic Architecture

The ENTER system architecture as outlined in (Figure 1), adopts an agent oriented approach to its design and implementation. The system is broken down into different functional components known as Agents [9][10][16]. The ENTER community of interactive agents exhibit characteristics that conform to both strong and weak notions of Agenthood [11]. There are five agents described that interact with each other to facilitate the realisation of ENTER, these are a *Design & Build Agent* (D&B Agent), *Presentation Agent*, *Login Agent*, *Listener Agent* and *Analysis Agent*.

Within ENTER worlds are initially created by a world designer through interaction with the *D&B Agent*. It is the *Presentation Agent* that is responsible for determining which particular view of a world is presented to a user and the actual displaying of this view. The presentation agent is able to interpret a unique user profile created and maintained by the *Analysis Agent* and the *Login Agent* respectively and manipulates the *world description files* where necessary. When the initial worldview is presented to a user, the *Listener Agent* monitors user activities and through the maintenance of user profiles the *Analysis Agent* indirectly informs the presentation agent of the user's interactions within the world. The *Analysis Agent* examines the user activities supplied by the *Listener Agent* which may lead to an update of the users profile, it then if deemed necessary prompts the *Presentation Agent* to dynamically reconfigure the world to suit a users perceived needs.

In order to describe the object's used by the world description files we utilise the Virtual Reality Modelling Language (VRML)[12]. VRML files can be viewed over the Internet in any standard web browser, there is also the ability to embed video, audio and objects called 'Sensors' within a VRML world. The sensors are used by the *Listener Agent* and allow us to monitor user activity and movements within a world. VRML allows the addition of script Nodes to add functionality to a scene, however in order for the agent community to control the VRML scene we make use of a set of JAVA classes known as the EAI [14] (External Authoring Interface). This set of classes can directly manipulate the CosmoPlayer [20] browser that displays the VRML scene thus allowing for VRML nodes to be dynamically added and removed from a scene and user actions to be monitored externally.

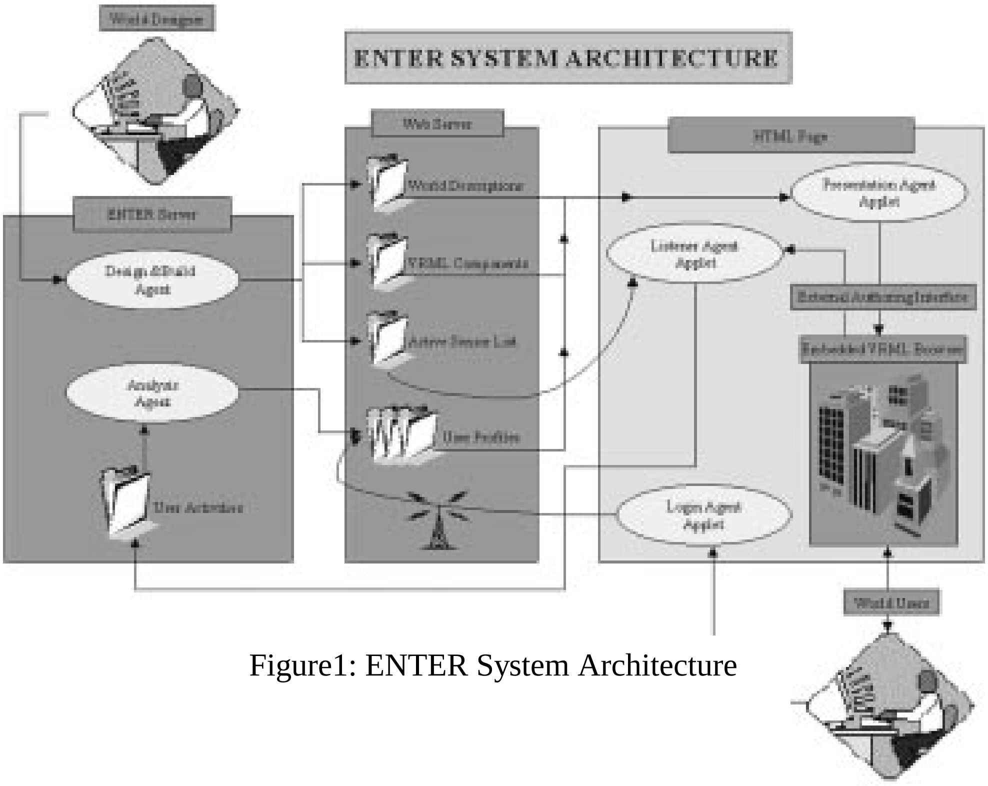


Figure1: ENTER System Architecture

4. ENTER Agent Overview

4.1 Design & Build Agent.

The Design and Build Agent is charged with supporting the user in the rapid prototyping of the 3-dimensional

Worlds. At present the worlds supported in the construction process adhere to a physical metaphor, specifically buildings with associated exteriors and interiors. The user is guided through a series of steps which collectively specify the external view (figure 2), form and the nature of buildings and positions them using a grid with each cell in the grid having unique coordinates.

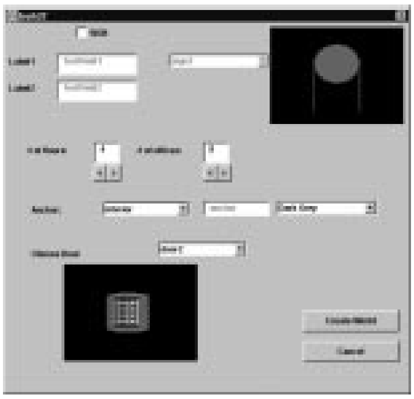


Figure 2: Exterior Interface

Each of the buildings is then populated with *contents* (Figure 3). The contents are selected from a *design palette, which* is contextualised given the nature and function of the building.

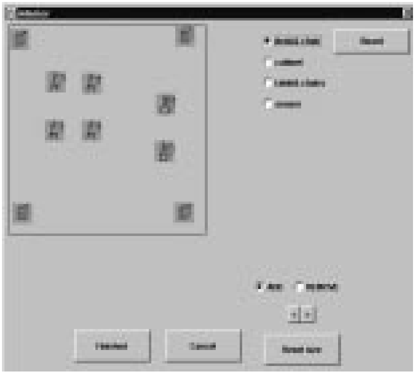
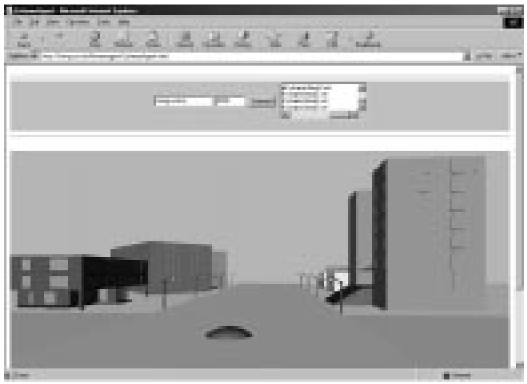


Figure 3: Interior Interface

For example a supermarket design pallet would typically contain shelves, products, trollys, cash registers and so forth while that of an office would typically contain desks, tables and chairs, filing cabinets and fax machines [15].The *D&B agent* draws upon a library of VRML components and produces world description files that describe the positioning of these components and their context within a world. The *D&B Agent* also facilitates the positioning of sensors that are used by the *Listener Agent* to accrue the raw data relating to user behavior. The VRML components, World Description files and the *active sensor list* are placed on a standard web server enabling access by the *Presentation Agent* over the Internet.

4.2 Presentation Agent.

The *Presentation Agent* is responsible for displaying a desired view of a given world. Central to the functionality of the *Presentation Agent* is its ability to understand the *World Description files*, which define the position and orientation of VRML components within the world, rather than reverting to a lower level VRML description of the scene. The presentation Agent is then able to manipulate the object types in the world description files using high level pre-defined *World Transform functions* including *inter alia:* Swap(ObjX , ObjY) , Move(Obj , Ref) , Rotate(Obj,Axis,Radians). Applying these functions to update the world description file can thus portray scene changes. The judicious choice of when and what transformations to apply is made by the presentation agent through interaction with the listener agent based on user events and the user profile, thus appropriate reconfiguration can be achieved. (Figure 4).



(i)Before Swap Activation

(ii)After Swap Activation

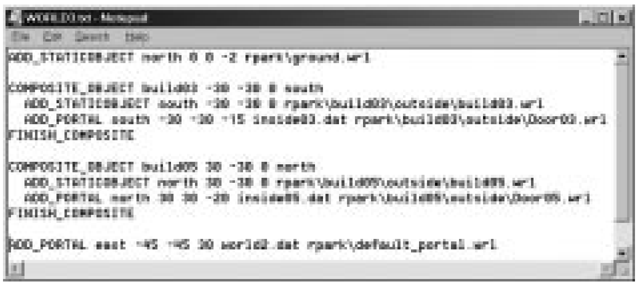
Figure 4: Dynamic Reconfiguration

There are 3 basic object types that are used to describe a world and which the presentation agent manipulates to provide alternate customised views. These are static objects, portal objects and composite objects.

Static objects:
Static objects constitute VRML components that have no functionality ascribed to them within the context of the scene description but may however have functionality within the scope of VRML for audio and video. For each static object the relative position of the object to a higher level VRML transformation is specified along with its orientation (whether it faces north, south, east or west). Each static object has an associated .wrl file that gives the 3-dimensional description of the object.

Portal Objects:
The portal object extends the static object type in that it has a destination World Description file associated with it. Portal objects are in essence standard VRML nodes with sensors attached. Standard VRML EventOuts [12] are registered by the *Presentation Agent* through the EAI and a new world description file is displayed.

Composite Objects:
These are a combination of both static and portal objects that are grouped together under a higher level VRML transformation in order that component objects can be manipulated within the world relative to one another. This enables buildings to be placed within a world, where the buildings themselves are static objects and the doors of the buildings are portal objects. Composite objects can themselves contain Composite objects which enables the creation of feature rich World Descriptions (Figure 5).



```
ADD_STATICOBJECT north 0 0 -2 rpark\ground.wrl

COMPOSITE_OBJECT build03 -30 -30 0 south
  ADD_STATICOBJECT south -30 -30 0 rpark\build03\outside\build03.wrl
  ADD_PORTAL south -30 -30 -15 inside03.dat rpark\build03\outside\Door03.wrl
FINISH_COMPOSITE

COMPOSITE_OBJECT build05 30 -30 0 north
  ADD_STATICOBJECT north 30 -30 0 rpark\build05\outside\build05.wrl
  ADD_PORTAL north 30 30 -20 inside05.dat rpark\build05\outside\Door05.wrl
FINISH_COMPOSITE

ADD_PORTAL east -45 -45 30 world2.dat rpark\default_portal.wrl
```

Figure 5: Sample World Description file.

4.3 Login Agent

The *Login Agent* is responsible for collecting initial information about users prior to their entry into the virtual world. This information is used either for creating a new user profile or accessing / updating an existing one. Within the ENTER system each world user is assigned a unique reference number which is used as a primary key to access their profile. The *Login Agent* intially accumulates all the personal details of a user e.g name, age, sex, nationality etc. (Figure 6) and this is used to instantsiate a generic user profile thus creating an initial user profile that can be updated if required.

Figure 6. Personal Details

When an existing user logs on the *login agent* prompts the user to select their preference for that particular session (Figure 7) and these session preferences are reflected within the virtual world. The login agent collects the user login information through use of standard HTML forms and informs the analysis agent of any changes the user wants to make to their profile thus insuring that a user gets an optimised view relevent to their current interests.

Figure 7. Session Preferences

4.4 Listener Agent

The *Listener Agent* collects information about a particular user's behavior within the virtual world by monitoring the activation of the sensors specified in the Active Sensor List. During the construction of the initial world view using the *Design and Build Agent* a facility is available to attach VRML sensor nodes to world components (doors, offices, buildings etc.) and an *active sensor list* is created. This list represents a simple text file that contains the unique names of all active tracking sensors used to monitor the user actions in the VRML world. This unique list is used by the *Listener Agent* to distinguish tracking sensors from sensors that are placed in the world that merely trigger simple actions.

To be able to receive events from the virtual world the *Listener Agent* is implemented as a JAVA applet embedded in the same page as the VRML browser for viewing the world. Both are connected and communicate through the EAI [14]. The unique sensor names are used as a reference to index a lookup table that stores a description of the sensor's location and context within the virtual world. In addition each sensor can provide the time of its activation which allows the *Listener Agent* to calculate how long a user spends in certain areas thus providing the *Analysis Agent* with a richer information set upon which to augment user profiles. The *Listener Agent* keeps a record of the user activities in a simple text file (Figure 8) referred to as the *user activity file* which the *Analysis Agent* parses and makes inferences on this in order to update the user profile.

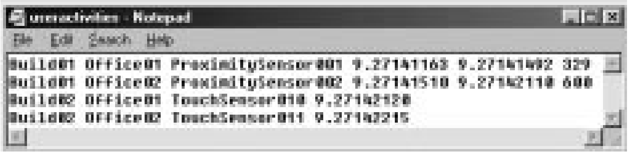


Figure 8: User Activity File

4.5 Analysis Agent

In order for the system to behave in a proactive and intelligent manner, meaningful assertions about an individual users preferred view of the virtual environment have to be made. The *Analysis Agent* is informed of user activities and movements from the *user activity file* supplied by the *Listener Agent.*This information is interpreted by the *analysis agent* and a user profile is constructed upon inferences made about the data. This user profile is utilised by the *presentation agent* to present a tailored view of the world according to the users tendencies.

User profiles are at present outputted using a weighting algorithm, where each subject is assigned a weight: a numeric value between 1 and 100 that represents user preferences, the higher the number the more the user is interested in that area. If a user spends a long time in a particular area e.g. HMV (Record Store) that areas weight can be incremented in the *user profile*.

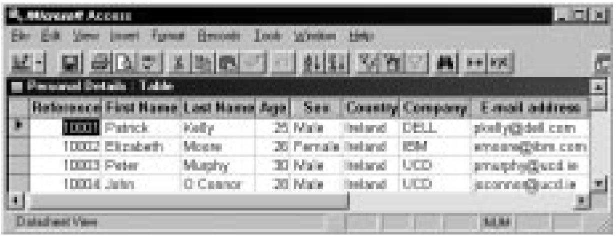


Figure 9: Personal Details Table

The resulting *user profile* produced by the *analysis agent* is at present stored in a simple database consisting of two tables that are indexed by the *presentation agent* using the user Reference Number as a Primary Key (Microsoft Access is the database of choice at present). The first table (Figure 9) stores the users personal details while the second table (Figure 10)stores the analyzed data. More than one table can be used when the system keeps a record of more than one browsing session. .

The adoption of an agent orientated design enables the easy incorporation of a higher level inference methodology such as Cased Based Reasoning [9] to construct the *user profile.* The format of the *user profiles* remains closely connected with the retail domain of ENTER, and as such can be easily adhered to by more advanced inference techniques.

Figure 10: Weighted Data

5. Discussion

Within the ENTER system one of the key thrusts of the research was the ability to dynamically reconfigure the world within which the user is situated. In a shopping sense this is clearly not new. For many years now large supermarket chains have had a policy of frequent changes in product placement policies, with the specific aim of disorientating the user and thus causing them to be exposed to more products that they may ultimately be disposed to purchase.

Within the ENTER system we recognise, and take cognizance of, the fact that there exist differing classes of shopper. For example some shoppers, strekers are only interested in the efficient acquisition of a particular product. Others enjoy the social experience of the shopping activity and are less goal directed.

The dynamic world reconfiguration that we are able to achieve within ENTER would clearly only be activated in response to firstly certain events and secondly certain user classes.

Additional difficulties associated with user disorientation and the dynamic reconfiguration of regions of worlds within which other shoppers are currently situated are being addressed. Reconfiguration would generally only be a local operation effecting merely the immediate foreground of the particular shopper. Indeed it would more often than not be the situation that reconfiguration can only be achieved where co-occupation did not occur. However there is ultimately no reason why the same view needs necessarily to be presented to multiple users even if the co-occupy the same vicinity. Two users located in almost the same position could be presented with starkly differing worldviews. We need merely to ensure that the virtual community view remains consistent in that other shoppers that are within view are perceived by fellow shoppers.

6. Conclusion

This paper has presented the ENTER system an immersive multi-user 3-dimensional system. This system has in the first instance been cast in the arena of virtual shopping malls but of course this represents but one potential application domain.

System innovation manifests itself in three primary respects:

Firstly it offers user immersion in both a virtual world and that of a virtual community. On going research efforts have concluded that whilst user immersion in a virtual world is often beneficial, immersion and social inclusion in a virtual connected community is crucial. Social and professional relationships can emerge as recurrent encounters are made between avatars within the virtual world, recognition becomes more natural. In many environments shared experience maps, in the form of shared memories exist which can significantly empower group activity. Effective communication and collaboration with co-inhabitants is fundamental to effectiveness in goal accomplishment in all forms of reality.

Secondly it supports dynamic world reconfiguration so yielding personalised and contextualised user views. In the retail domain, information and service presentation based on perceived user needs are a key to market penetration. The classical world of retailing has long recognised the importance of product location. In the ENTER environment this can be achieved based upon an individual user profile where products and services most relevant to an individuals needs are assembled in the foreground while those of less relevance are pushed into the background.

Finally all of this is achieved through the judicious use of agent oriented techniques. A community of intelligent agents collectively monitor user interactions with the world and subsequently collates and analyses this, extracting features and updating user profiles based on this. Based upon these profiles tailored information presentation is delivered. At all times end user is blissfully unaware of the very existance of the agent community.

Current research focuses on potential view inconsistencies that may occur as users are presented with varying views of the same locality. We are currently investigating ways through which this may be addressed, such that certain common information layers can be presented consistently across all views of an environment, thus acting as referential anchors with personalised information merely overlaid on top, in essence a parallel reality.

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